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ABSTRACT

The purposes of this study were to investigate: (1) effectiveness of three small group teaching methods on the acquisition and retention of seriation abilities; (2) transfer of seriation abilities using the three treatments; and (3) relationship between visual and nonvisual seriation abilities. One hundred twenty first grade Canadian students were administered Piaget's stick seriation task and then classified as either Stage I (nonseriators), Stage II (some operational abilities) or Stage III (operational seriators). Twenty-four children from each stage were randomly chosen and randomly assigned to one of three treatment groups. Each treatment-group was further divided into subgroups of six children who received their treatment together. It was concluded that the testing and training experience with the nonvisual materials had a positive transfer effect on this Piagetian task. (HM)

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The Effect of Small Group Teaching on Acquisition and Transfer of Nonvisual Seriation Abilities

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The Effect of Small Group Teaching on Acquisition and Transfer of Nonvisual Seriation Abilities

Michael Padilla and Lloyd Ollila

Seriation tasks have been included as an expectation or goal of several science and early childhood education programs. From those funded by NSF like Science Curriculum Improvement Study (1970) and Science-A Process Approach (1967) to the newer programs like Space, Time, Energy and Matter (Rockcastle et.al., 1975) the Modular Activities Program in Science (Berger et.al., 1974) and the Early Childhood Curriculum (Lavatelli, 1973), seriation has played a prominent part in the activities that young children are asked to perform. The basis for the inclusion of this task comes from many quarters (Schwebel and Raph, 1973, Maxwell, 1974). Henry (1978), for example, states "Science programs involving activities in classification and seriation could be expected to develop the operations associated with class inclusion and assymetric relations...." Yet science educators with few exceptions have ignored questions about the teaching aspects of this task as it relates to different kinds of materials and the developmental level of the learner. It is the intent of this paper (1) to determine the effectiveness of three distinct, practical, small group teaching methods on the acquisition and retention of seriation abilities; (2) to investigate transfer of seriation abilities relative to the three treatments; and (3) to investigate the relationship between visual and nonvisual seriation abilities.

Inhelder and Piaget (1964) in their original work with seriation described three basic stages of seriation behavior. Stage I children could not order a set of ten sticks by length. Stage II children could order the sticks correctly, but could not insert an additional set of ten sticks into the already ordered row. Stage III children could both order and insert correctly and were considered operational seriators. While this research emphasized the purely

developmental aspects of the task, the present study attempted to broaden the scope of seriation research by considering not only developmental aspects, but also, and primarily, curriculum and teaching considerations.

Both Smith and Padilla (1977) and Baylor and Gascon (1974) found that when young children successfully perform a seriation task, they basically use one of two distinct, systematic strategies. Padilla (1975) developed teaching methods for these two strategies and a control and found that grade one students can learn to use the strategies when individually trained. In addition one strategy proved particularly helpful to stage I children on an immediate posttest and in transfer of training. This strategy was the basis for one treatment (called EVS) in the present study. Schafer (1975) reported that individual training using corrective feedback, attention to task stimuli and other instructional methodologies produced substantial and durable seriation behavior changes. These results along with success reported for a similar treatment in Padilla (1975) form the basis for the second treatment (called CON).

Since it was hoped that the present study would have immediate practical application to the classroom, the treatments were designed to mirror common strategies generally used in elementary classrooms. Thus the EVS is a directly taught strategy for seriation while the CON involved task directions, practice and feedback but no directly taught strategy. The third treatment involved no task directions or practice, but only creative use of the materials to be ordered. Thus this treatment was thought to emulate the classroom where materials were made available, but no teaching or task directions are given; children were left to discover the relationships on their own.

A marked discrepancy between ordering objects on visually apparent (e.g., length) variables as compared to nonvisually apparent (e.g., weight) variables

has also been reported. Inhelder and Piaget (1964) report that most children develop length seriation abilities by age 5-7; weight seriation appears to follow one to two years later at age 6-9 (Piaget and Inhelder, 1941; Smith and Padilla, 1977). However, Padilla (1975) found that when children are taught seriation strategies and allowed to practice with nonvisual objects that most were able to order nonvisual objects regardless of age or visual seriation ability. In fact fully one-third of those children who practiced with the nonvisual objects also improved their abilities with sticks on the posttest. The present study hopes to replicate these findings with small group, not individual, teaching methods.

Procedure

One hundred and twenty first grade students from two average Victoria, British Columbia public schools were chosen for this study. Each was individually pretested with the stick task used by Inhelder and Piaget (1964) and classified as either stage I, II, or III seriators. Of the 25 stage I, 57 stage II and 38 stage III children, twenty-four from each stage were randomly chosen for inclusion in the study. Groups of four children within each stage were randomly selected and two groups from each stage were randomly assigned to one of three treatments. These groups were then randomly assigned to one of three trainers.

The treatments used in the study are as follows: the Extreme Value Selection strategy (EVS) involved the repeated selection of the unordered object with the greatest value and placement of that object next in the row until an entire row was completed. Thus, these children were taught to test each object to find the heaviest or roughest and place that first in the row. Then they repeated their actions to find the second heaviest or roughest and placed it next. This process continued until all the objects had been placed

in order. The Control (CON) treatment involved no specific strategy training. Instead these children were informed of the task objective, were given much opportunity for practice and were given feedback on task accuracy. They formed or did not form their own methods for task completion. The Placebo (PLAC) treatment involved no task training or information about the ordering task. They were encouraged to find creative ways of observing and exploring the training materials, but their energies were not channeled in any specific direction.

Two different sets of materials, alike on all variables but one, were used for training and testing. Eight cups ranging in mass (10 to 2100 gm) were used for ordering on mass. Eight cylinders with materials of varying textures (smooth acetate to 40 grit sandpaper) glued to the inside surface were used for ordering on texture. In addition eight pipes with handles that took a varying amount of force (.8 to 11.25 lbs.) to pull were used for ordering on force as a test of transfer on the post and retention tests. All members of each materials set were alike except on the variable of interest.

All the subjects in a group received the same treatment. Four distinct sessions, each separated by one or two school days, alternately employed the weight or texture materials for training. Each session lasted approximately fifteen minutes.

For those in the EVS and CON groups, the sessions began with an introduction to the materials and the task. Each child was asked to observe a properly ordered set of four objects as the task was being orally described. Treatment training followed.

For the EVS children, the treatment was modeled and orally described in steps. After each modeling-description step the children were asked to perform the same action on their materials. Task and treatment feedback were given

during this time. A step involved the systematic choosing of the maximum object (heaviest or roughest) and placing that object in its proper place in the row. After completing three successful steps the children were encouraged to finish the task on their own. For the rest of the training period these children practiced the task and were given feedback. Those who did not catch on at first were given individual help until they were successful or until the session ended.

The CON children were only told to "...put them in a row from heaviest to lightest (or roughest to smoothest)." When they finished, they were given feedback as to correctness and told to continue practicing.

The PLAC children were encouraged to observe and explore their materials in creative ways, some of which might involve observing the objects on the variables of interest and actually ordering on those variables. No introduction to the task or materials was given.

Within two or three school days of completing the training, all children were individually posttested. This test included one chance to order the weight, texture and force materials as well as the stick task (Inhelder and Piaget, 1964) given as a pretest. Approximately three months later the same tests were repeated as a retention test.

A task accuracy score (TS) was collected for each task on the pre, post and retention tests. This score was computed by calculating a Kendall's Tau correlation between the child's ordering and the true order. Thus, this score reflected the degree to which the child's ordering matched a perfect ordering.

A 3 x 3 factorial design was employed in which three levels of treatment (EVS CON and PLAC) were fully crossed with three levels of stage (I, II, III). An alpha level of .05 was set for significance, but probabilities up to .10 were reviewed since defining and inferring relationships was the major intent of the study.

Reliability and Validity

Each trainer spent approximately eight workshop hours practicing training procedures to a mastery level. In addition, each followed a general training protocol for each of the treatments. Testers, too, underwent a minimum amount of training--approximately four hours. All quickly reached and maintained 95% concurrence with each other and a master trainer. No trainer tested children from within treatment groups that he taught. Face validity for the measures is claimed.

The specific questions addressed in this study are the following:

1. Can practical, small group teaching methodologies prove as successful in teaching nonvisual seriation as individual methods?
2. Will any of the three treatments result in higher mean task scores as an immediate posttest?
3. Will the high mean task scores be retained over three months time for any treatment?
4. Will any treatment better facilitate transfer to a new set of nonvisual materials on the posttest?
5. Will any treatment better retain transfer abilities over three months time?
6. What effects will the treatments have on children's visual stick seriation abilities on post and retention tests?

Results

Table 1 presents the means and standard deviations of all treatment-stage groups for both post and retention tests. By comparing the posttest results on this study to those obtained on a previous study (Padilla, 1975) which used individual training methods with the EVS and CON treatments, it can be readily seen that similar high scores were attained. [Mean posttest TS in Padilla (1975) were EVS III = .95, EVS I = .93, CON III = .94, CON I = .80.] The retention test results of the two studies are also quite similar. [Mean retention test TS in Padilla (1975) were EVS III = .93, EVS I = .75, CON III = .91, CON I = .74.]

No PLAC treatment or stage II children were used in the earlier study. Yet comparisons of the common groups indicate that small group testing methods as described in this paper can prove as successful as individual training. Thus the first hypothesis is accepted.

A two way analysis of variance (ANOVA) was performed on the posttest mean TS's of all treatment-stage groups (Table 2). A main effect due to treatment was apparent ($p<.00$). Post hoc analysis showed that both the EVS and the CON scored higher than the PLAC ($p<.01$ and $p<.05$, respectively). A significant difference due to stage ($p<.00$) was also apparent. However, because stage differences were not the major focus of this study, none will be discussed in the following analyses. The reader can reconstruct this data from Tables, if desired. A significant interaction effect ($p<.02$), when graphed, showed that the EVS I children performed significantly higher than the other stage I children and up to the levels of the stage III subjects. Thus both the EVS and CON treatments proved more effective at raising task performance than did the PLAC and the EVS proved more effective than either treatment with stage I children.

The retention test data show that all treatment-stage groups performed at levels comparable to posttest levels except the EVS I which dropped considerably. An analysis of variance (ANOVA) on this data (Table 3) showed a significant difference due to treatment ($p<.00$). Post hoc analysis indicated a difference between the CON and PLAC treatments only ($p<.10$). Thus training was retained by all groups except the EVS I which dropped considerably and showed a substantial increase in variability on the retention tests.

Table 4 reports the means and standard deviations of the transfer task for both post and retention tests. An analysis of variance (ANOVA) on the posttest results (Table 5) shows a significant difference due to treatment

($p \leq .01$). Post hoc analysis showed EVS children scored higher than PLAC children ($< .10$) but did not show any other differences. An analysis of variance (ANOVA) was also performed on the retention test transfer data (Table 6). Significant differences due to treatment were evident ($p \leq .00$) with post hoc analysis showing that the CON performed higher than the PLAC. Thus the post and retention test analyses of transfer task data show conflicting results. The EVS groups while superior on the immediate posttest decreased in performance over time while the CON groups increased on retention tests.

All subjects were given Piaget's stick task as a pretest. By definition all stage III children could both order sticks (i.e., TS = 1.00) and insert a set of five sticks into the ordered row. All stage II children could order the sticks (TS = 1.00) but could not insert the entire set of five. The stage I children could neither order nor insert correctly. The same task was repeated during the post and retention test sessions and Table 7 reports the results. Stage III children with a few exceptions continued their high ordering and insertion abilities. Stage II children performed steadily on the ordering task and increased on the insertion task for the post and retention tests. Stage I children increased on both the post and retention tests for the ordering and insertion tasks, although all treatments showed a fairly high degree of variability. The above increases seem to favor no specific treatment and are difficult to interpret. Two separate hypotheses could account for the increases. The results could simply be a consequence of test-retest learning. Although no information has been found regarding this phenomenon with the seriation task, test-retest learning has been shown with some of Piaget's formal operational tasks (Lawson et.al., 1974). Secondly, it is possible that work with nonvisual materials which could be ordered gave the stage I and II children the necessary experience to be able to assimulate and accomodate the necessary structures for the seriation task. Further research in this area is necessary.

Conclusions

Several conclusions can be drawn from the data. Small group work with nonvisual materials can be as successful as individual training methods. This is practically important for teachers because most classroom situations cannot allow completely individualized training.

While the EVS and CON were more effective on the posttests than the PLAC and the EVS children scored higher than either the CON or PLAC for stage I children, the differences favoring the EVS vanished on the retention tests. Similar results showed the EVS group scoring highly on a posttest transfer task but dropping on the retention transfer task. The CON group on the other hand increased their scores across all stages from post to retention test.

Results similar to these were reported by Padilla (1975) and it appears that now a general conclusion can be drawn. While the EVS is more effective in producing short term task accuracy in those children who do not have the necessary logical structures (stage I children), the strategy appears to create only rote learning which is lost over time. For stage I children the EVS does not meet Piaget's two criteria, namely "Is the learning lasting? What remains two weeks or a month later? and How much generalization is possible?" (Piaget, 1965). The CON treatment on the other hand forces a student to reorganize his own structures in order to correctly solve the task. It can generally be labeled a "cognitive conflict" strategy (Smedslund, 1961). The burden of cognitive reorganization is on the learner himself. The treatment only feeds back "correctness" information that the learner must assimilate and accomodate. Thus, the results with the CON treatment lend strong support to Piaget's equilibration model.

What, then, should the role of training be in the classroom? What treatment should children experience? It appears that the results clearly show

that either the EVS or CON is acceptable for stage II or III children and that the CON is the treatment of choice for stage I children. The EVS, while producing immediate results, will not bring about lasting changes for those in stage I. It is also interesting to judge the results of all children's nonvisual seriation abilities against Inhelder and Piaget's (1941) insistance that seriation with weights follows that of sticks by two years. It is evident that the training procedures and work with materials like those in this study bring this statement into question.

Table 1

Means and Standard Deviations on Post and Retention Test Mean Task Scores (TS)
(n = 8 per treatment-stage group)

Treatment/Stage	Posttest $\bar{X}$	Posttest S.D.	Retention Test $\bar{X}$	Retention Test S.D.
EVS III	.94	.06	.93	.05
CON III	.97	.04	.93	.05
PLAC III	.83	.16	.82	.16
EVS II	.96	.06	.95	.05
CON II	.95	.06	.93	.07
PLAC II	.77	.20	.73	.23
EVS I	.92	.12	.68	.28
CON I	.80	.25	.78	.13
PLAC I	.44	.25	.50	.26

Table 2

ANOVA Table for Mean Posttest Task Score Results.

Source of Variation	Sum of Squares	df	Mean Square	F	p<
Treatment	.986	2	.493	20.28	.00
Stage	.524	2	.264	10.86	.00
Treatment x Stage	.311	4	.078	3.20	.02
ERROR	1.532	63	.024		

Table 3

ANOVA Table for Mean Retention Test Task Score Results.

Source of Variation	Sum of Squares	df	Square	F	p<
Treatment	.521	2	.261	9.20	.00
Stage	.848	2	.424	14.96	.00
Treatment x Stage	.086	4	.021	.755	n.s.
ERROR	1.785	63	.028		

Table 4

Means and Standard Deviations of Post and Retention Test Transfer Task Score (TS) (n = 8 per treatment-stage group)

Treatment/Stage	Posttest		Retention Test	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.
EVS III	.96	.05	.94	.07
CON III	.86	.17	.95	.05
PLAC III	.65	.23	.79	.11
EVS II	.95	.07	.89	.07
CON II	.89	.13	.90	.09
PLAC II	.78	.14	.68	.21
EVS I	.76	.22	.60	.25
CON I	.66	.25	.78	.17
PLAC I	.62	.21	.49	.28

Table 5

ANOVA Table for Posttest Transfer Task Scores.

Source of Variation	Sum of Squares	df	Mean Square	F	p<
Treatment	.517	2	.259	8.25	.01
Stage	.479	2	.240	7.64	.01
Treatment x Stage	.083	4	.021	0.66	n.s.
ERROR	.1975	63	.031		

Table 6

ANOVA Table for Retention Test Transfer Task Scores.

Source of Variation	Sum of Squares	df	Mean Square	F	p<
Treatment	.634	2	.317	11.61	.00
Stage	.932	2	.466	17.07	.00
Treatment x Stage	.093	4	.023	0.85	n.s.
ERROR	1.719	63	.027		

Table 7

Mean Task Score and Number of Correct Insertions on Pre, Post and Retention Stick Tests by Treatment-Stage Group
(n = 8 per treatment-stage group)

Treatment/ Stage Group	Pretest		Posttest		Retention Test	
	Mean and S.D. of TS	Mean # of Correct Insertions	Mean and S.D. of TS	Mean # of Correct Insertions	Mean and S.D. of TS	Mean # of Correct Insertions
EVS III	1.00 (.00)	5.00	1.00 (.00)	4.63	1.00 (.00)	5.00
CON III	1.00 (.00)	5.00	1.00 (.00)	5.00	1.00 (.00)	4.75
PLAC III	1.00 (.00)	5.00	1.00 (.00)	4.88	1.00 (.00)	4.63
EVS II	1.00 (.00)	3.38	1.00 (.00)	4.50	.99 (.02)	4.25
CON II	1.00 (.00)	2.25	.98 (.05)	3.87	1.00 (.00)	4.50
PLAC II	1.00 (.00)	3.25	1.00 (.00)	4.13	.99 (.03)	3.63
EVS I	.62 (.22)	.00	.74 (.28)	.75	.77 (.32)	2.00
CON I	.44 (.33)	.00	.82 (.27)	2.13	.87 (.22)	2.25
PLAC I	.50 (.38)	.00	.73 (.39)	2.50	.84 (.31)	3.25

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